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THE MEASUREMENT OF TRACE ELEMENTS IN INTERPLANETARY DUST AND COMETARY PARTICLES BY ULTRA-HIGH SENSITIVITY INAA

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INTRODUCTION Today the major element composition of interplanetary dust particles (IDPs) is routinely determined in many laboratories. These and mineralogical studies have revealed the presence of at least two major types of IDPs, chondritic and refractory. Chemical and mineralogical data bases for IDPs have expanded to the point where workers are beginning to suggest possible parent bodies for some samples, and outline possible thermal-pressure-chemical histories as well [1-3]. This work generally involves analogies to meteorites. However, these comparisons remain at a primitive state partly due to the lack of trace element information from IDPs. Trace element analysis is geochemically important, with the potential for revealing details of condensation/crystallization processes, metamorphism, aqueous alteration, melting and partial evaporation. Most of these processes played important roles in the histories of IDPs, as well as comets from which many IDPs are certainly derived. There have been previous efforts to collect trace element data from IDPs, which have been successful for limited numbers of trace elements using INAA (Na, Sc, Cr, Fe, Co, Ni, Zn, Au[?] and Ir[?]), PIXE (S, K, Ca, Fe, Ni, Zn, Ge, Se and Br) and Synchrotron XRF (Cr, Mn, Fe, Ni, Cu, Zn, Ga, Ge, Se and Br) [4-6]. We report here preliminary results of a successful attempt to determine abundances of a large suite of trace elements from both chondritic and refractory IDPs. We then describe how our analytical procedure can be used in the grain-by-grain analysis of returned cometary samples.

EXPERIMENTAL PROCEDURE Chondritic and refractory IDPs are characterized by standard SEM-EDX techniques. In general, samples are not coated for these analyses in order to permit later analysis of intrinsic noble metals and carbon. IDPs analyzed to date have ranged in size from about 15-50 um in greatest diameter. These particles are sealed individually into high-purity silica tubes and irradiated for approximately 1 week in the highest possible neutron flux (3.0×10^{14} $cm^{-2}sec^{-1}$) in the reactor at the National Institute of Standards and Technology. The particles are then released from incarceration in the tubes, and are deposited between two fresh dimpled plastic slides. Gamma-ray spectrometry is performed using a large (55% efficiency) Ge detector in the ultra-low level Radiation Counting Laboratory at the NASA Johnson Space Center. This unique laboratory was specially designed and constructed to minimize natural background radiation. With our system, detection limits for many elements are well below picogram levels, and some approach femtograms. This technique is non-destructive, although some sample handling is required, so particles can be analyzed by other techniques after INAA is completed.

RESULTS We are presently reducing data from the analyses of 7 IDPs. These are U2015E10, U2015F1, W7029*A2, W7029*A3, W7013A8, LAC1 (all chondritic) and 705 (refractory). We have, so far, detected and measured 17 different major and trace elements in these particles, including rare earths and some very volatile elements (Br and Zn). We will present the final data at the workshop.

DISCUSSION Even the preliminary data we present here are sufficient to demonstrate that we can routinely measure a large suite of trace elements within IDPs, and samples of similar dimensions. With time we expect to build up a large data base of trace element data of IDPs of all types, which will permit us to more accurately determine the origin and histories of these samples. As many of the chondritic IDPs probably originate from comets, this research will, in a larger sense, reveal the geochemical processes active on comets. Of more direct value to this workshop, however, is that we are now in an excellent position to apply this technique to samples returned from a comet nucleus. Assuming that comets are largely aggregates of relatively unprocessed dust grains and ices, it will be necessary to analyze cometary samples on a grain-by-grain basis. Our INAA technique will permit the measurement of trace elements in the dust fraction of such samples.

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